

Crash Injury Mechanisms and Restraint Technologies –CIREN Research Update



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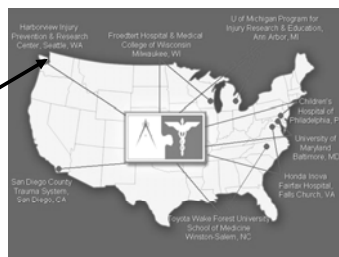
**Crash Injury Research and
Engineering Network**

Road Safety

- Roadway and Infrastructure
- Driver Behavior
- Vehicle Design
 - Crashworthiness



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Real world laboratory of motor vehicle crashes created by NHTSA in 1996.

Harborview Injury Prevention and Research Center is one of 8 trauma centers contributing to the CIREN network for NHTSA.

CIREN

**Crash Injury Research and
Engineering Network**

www.hiprc.org

nhtsa.dot.gov



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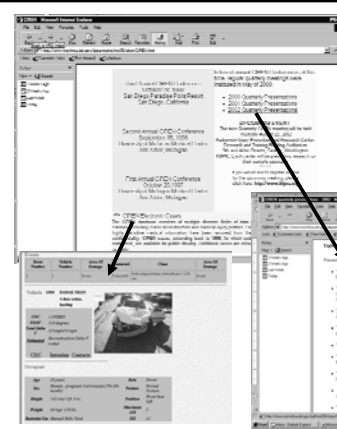
CIREN on the Web

Quarterly Presentations

Electronic Cases (Queries)

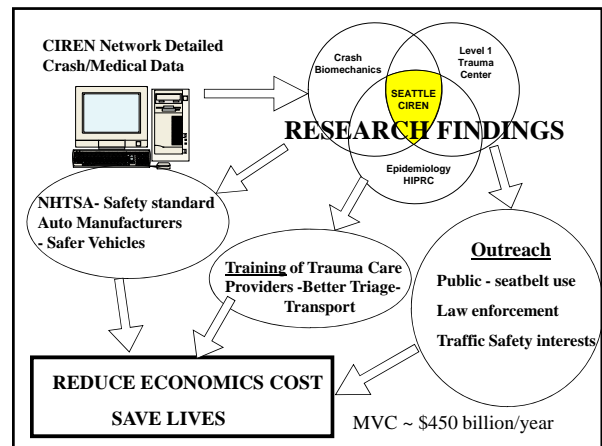
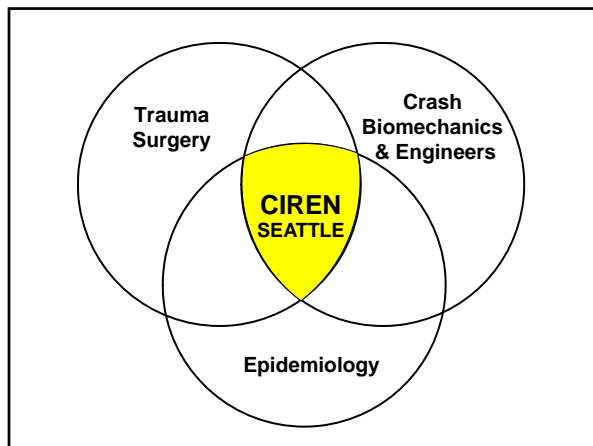
Injury Mechanism Themes

Annual Reports




CIREN Goals

- Provide data on injuries occurring in real world crashes
- Provide feedback on vehicle safety design for:
 - Auto manufacturers
 - FMVSS
- Provide outreach and training
- Determine and document specific injury mechanisms and forces in real world crashes.




Critical Clues at Crash

- Given a Damaged Vehicle → Injury



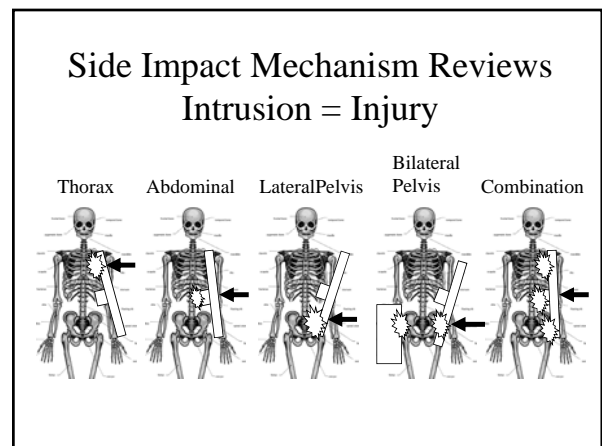
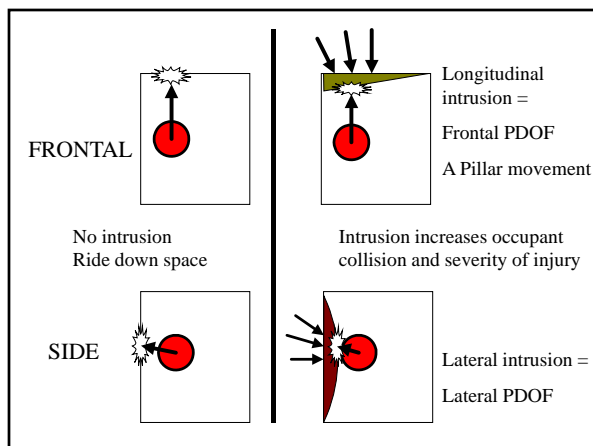
- Given an Injury → Direction of Force or type of crash



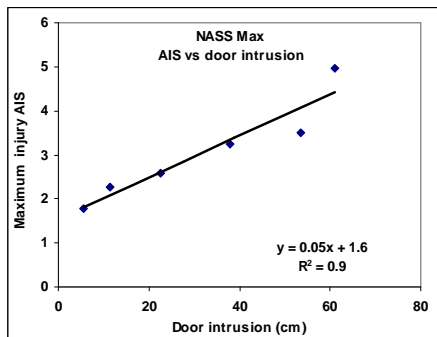
Critical Clues at Crash

One can determine an injury mechanism based on the following:

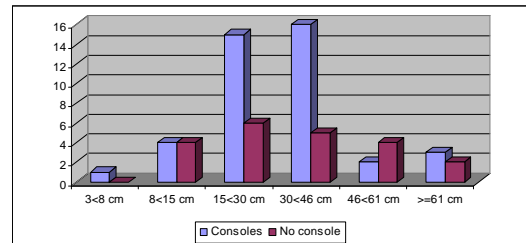
- Restraint status (most important)
 - witness, first responder, locked open, belt burns
- Seat Location
- Occupant compartment intrusion
 - Intrusion = Injury!!**
- How much Force, based on vehicle damage
- Direction of Force (most difficult)



Results – NASS MAIS v Door intrusion

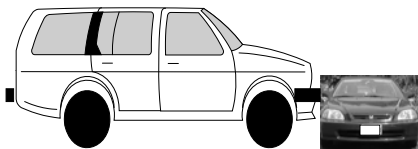


Moderate and serious pelvic injury in nearside crashes by magnitude of intrusion



Tencer A., Kaufman R., Mack C., Mock C. Factors affecting pelvic & thoracic forces in near-side impact crashes: a study of US-NCAP, NASS, and CIREN data. *Accident Analysis and Prevention*, In Press

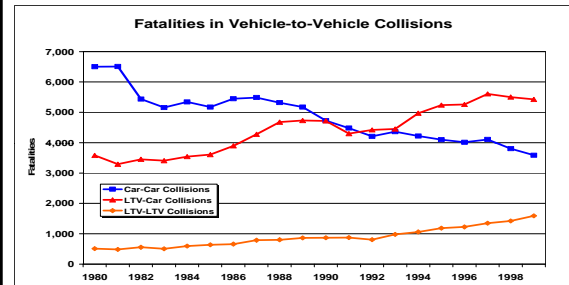
Larger Vehicle and Side Impacts



Incompatibility crashes

Some bumper heights are overriding the side impact supports

Increasing LTV-Car Fatalities



Intrusion = Injury



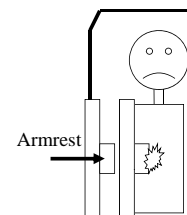
Think Thorax!!

Think Head, if external marks

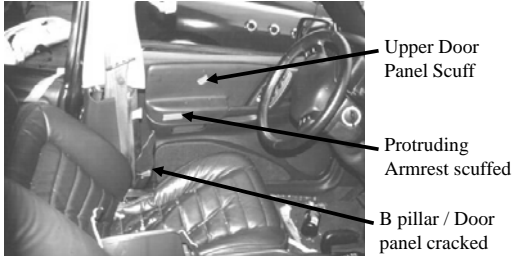
Abdominal Injuries Observed

- Side impacts appear to increase the risk of abdominal injuries

- The stiffness and geometry of the door panels along with the protruding components, such as the armrest appear to become forced into the abdomen of the occupant.

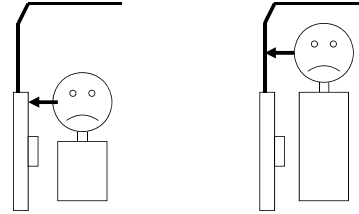


Occupant Contacts

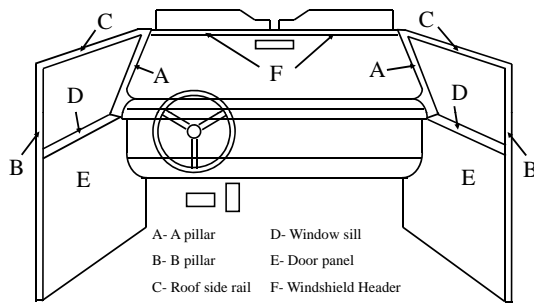


Head Injuries

Nirula R, Mock CN, Kaufman R, Rivara FP, Grossman D. Correlation of head injury to vehicle contact points using Crash Injury Research and Engineering Network (CIREN) data. Accident Analysis and Prevention, 35: 201-210, 2003.



Direct contact source for critical head injuries occur to roof structure, rails and pillars

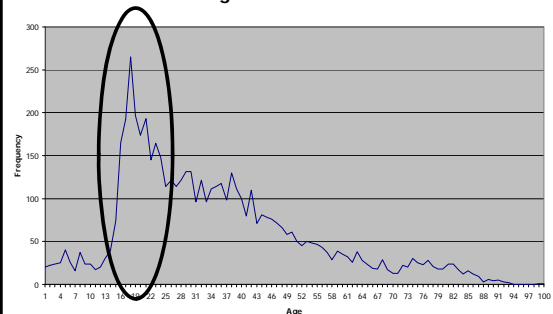


Side Airbags Provide Head Protection

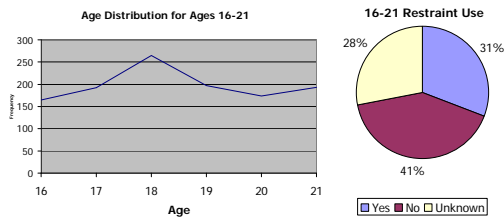
Frontal Crash Injury Mechanisms

Seattle CIREN - Tracking Data

Crash Victims at Trauma center
Age Distribution



Seattle CIREN - Tracking Data



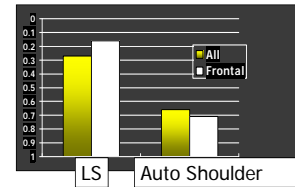
Total for group = 1186 (31%)

16-21 years olds make up 1/3 of the crash patients at the trauma center, and only 1 of 3 are belted

Relative risk of death compare to no restraints

Lap/shoulder 0.2 (86% reduction)

Shoulder only 0.7 (34% reduction)



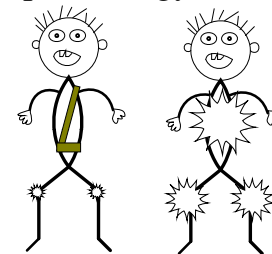
Rivara FP, Koepsell TD, Grossman DC, Mock C: Effectiveness of automatic shoulder belt systems in motor vehicle crashes. *JAMA*, 293; 2826-2828, 2000.

Seattle CIREN Research Publication (FARS data)

Rivara F, Cummings P. Car occupant death according to the restraint use of other occupants: a matched cohort study. *JAMA*. Jan 21;291(3):343-9, 2004

- Restrained occupants can have an increased risk of death by 22-25% with an unrestrained person in the vehicle behind or next to them.
- 1 out of 6 deaths may have been prevented if the other occupants were restrained
- To reduce the risk of death, all occupants must be restrained in the vehicle

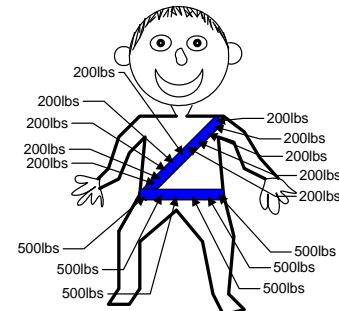
Occupant energy distribution



Restrained vs. Unrestrained/Intrusion

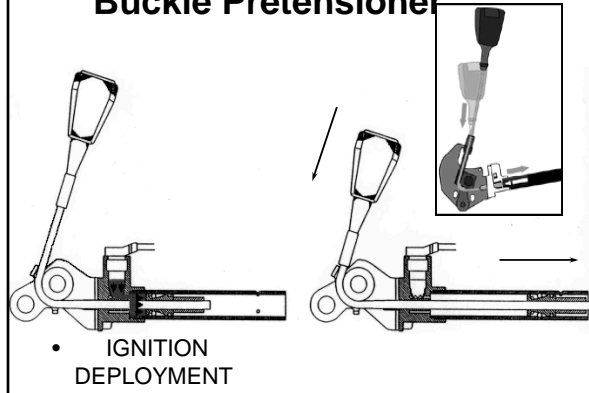


Padded Knee Bolsters

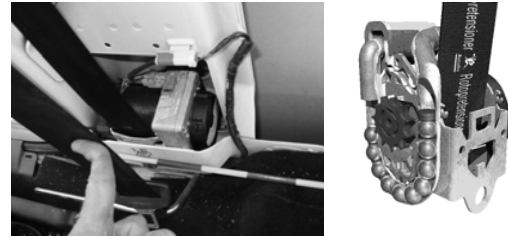


Seat belt distribution of force on body

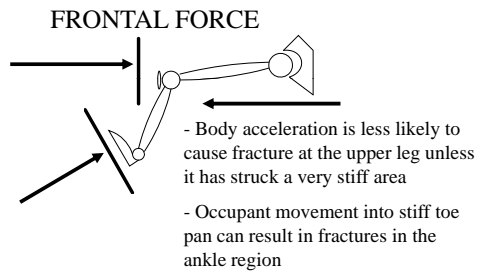
Buckle Pretensioner



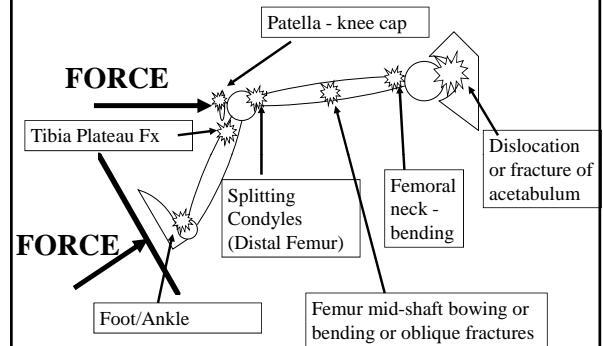
Safety Belt Retractor Pretensioner



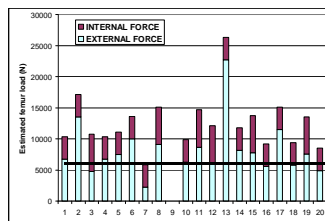
Direct Contact Forces to Lower Extremities



Axial load and force to lower extremity

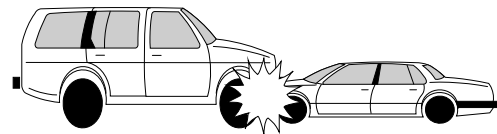


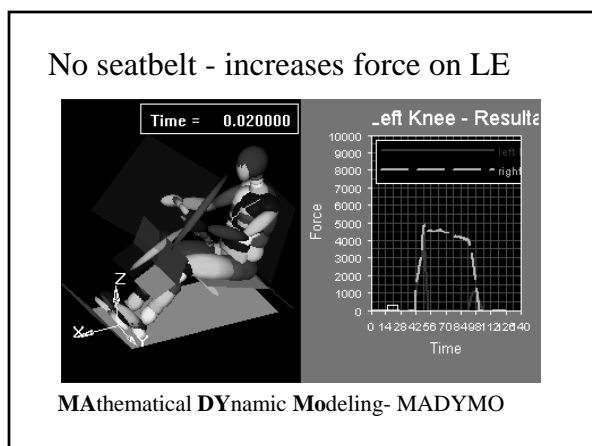
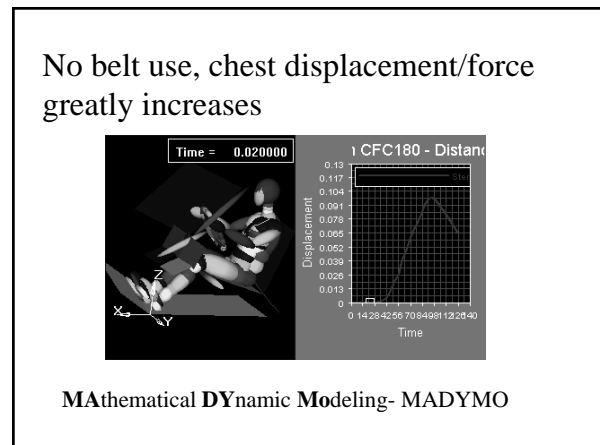
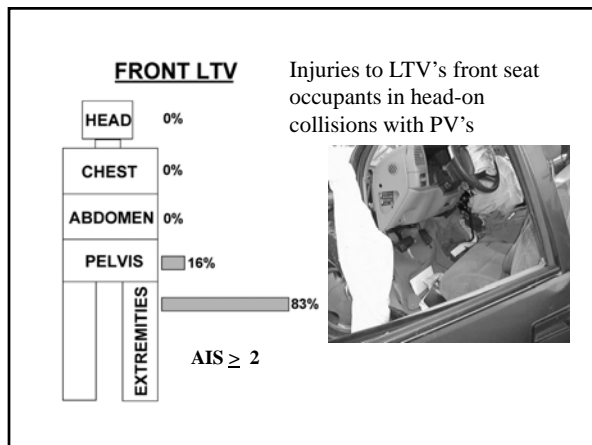
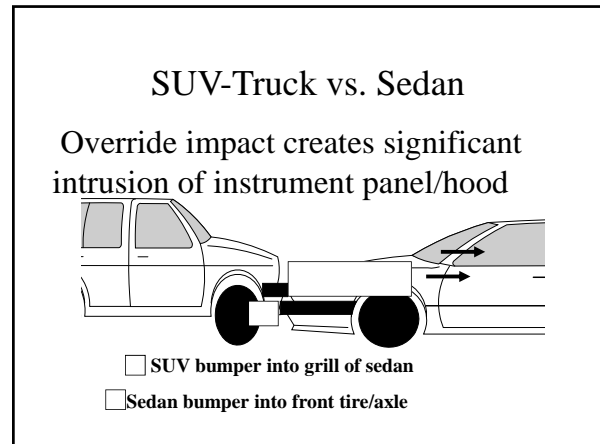
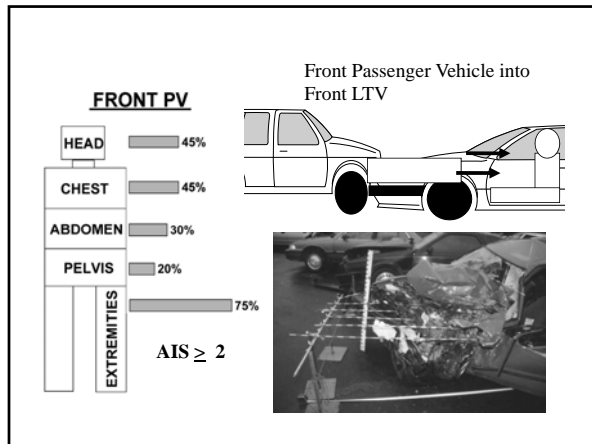
External and Internal Force Calculation



- Tencer A, Kaufman R, Ryan K, Grossman D, Henley MB, Mann F, Mock C, Rivara F, Femur fractures relatively low speed frontal crashes: The possible role of muscle forces. *Accident Analysis and Prevention*, 34(2002) 1-11.

Offset Frontal Impacts with Vehicle Mismatch



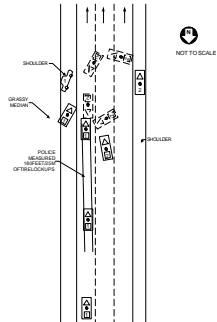


The Effects of Seatback Reclined Positions of Occupants in Motor Vehicles Collisions

Seattle CIREN Team (Bulger, Dissanaikie, Kaufman, Mack)
University of Washington
Harborview Injury Prevention and Research Center

Dissanaikie S, Kaufman R, Mack CD, Mock C, Bulger E. The effect of reclined seats on mortality in motor vehicle collisions. *The Journal of Trauma, Injury, Infection and Critical Care*. 2008 Mar;64(3):614-9.

Seatback Recline CIREN Case Review 1 – Scene



Head-on
Full frontal crash
Speed Limit
70mph/112kmph

Seatback Recline CIREN Case Review 1 – Vehicle



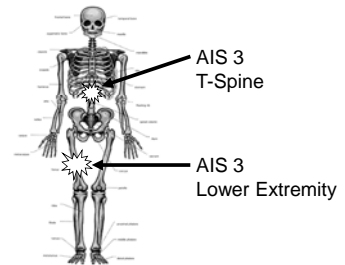
2003 Compact 4 door sedan
PDOF – 12 o'clock
Delta V = 44kmph/ 27 mph (smash missing run)

Seatback Recline Case Review 1 – Case Occupant

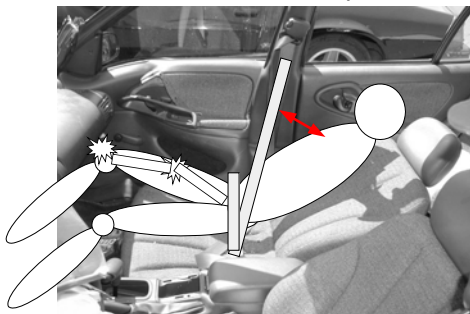


20's yr. – Female
Lap/shoulder & Air bag
Fully reclined seatback position and sleeping

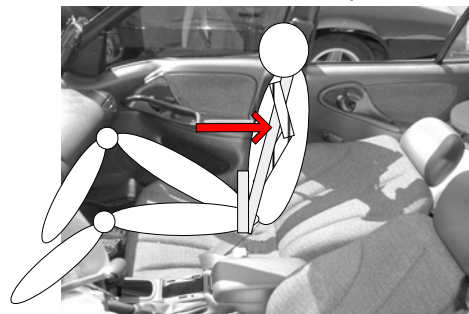
Seatback Recline CIREN Case Review 1 – Injuries



Seatback Recline Case Review 1 – Occupant Kinematics



Seatback Recline Case Review 1 – Occupant Kinematics



Demographics

	Upright (17.6%)	PR (50%)	FR (0.3%)
Age (yrs)	39.4	35.7	29.6
Male gender (%)	7775 (48.8%)	24705 (54.7%)	197 (70.4%)
Height (cm)	170.1	171.4	174
Weight (kg)	75.9	75.8	79

Mortality risk – regression analysis

- Difference in mortality persist when adjusted for age, sex, seatbelt use and type of vehicle

Mortality Risk	Odds Ratio	95% CI
Partial Reclined	1.14	1.02 – 1.22
Fully Reclined	1.77	1.13 – 2.78

Conclusion:

- Fully reclined occupants are predominantly young, male and not wearing a seatbelt
- “Clothesline” type
 - Chest and spinal injuries with the shoulder belt appear to be one mechanism in fully reclined occupants wearing a seatbelt.
- **Fully reclined seats are an independent risk factor for death in motor vehicle collisions**
- Slightly reclined seats have a small increase in mortality

An Evaluation of Spinal Cord Injury (SCI) Associated with Motor Vehicle Crashes including Rollovers

Eileen Bulger, MD
Robert Kaufman, BS
Chris Mack, MS
Stephen Burns, MD



University of Washington



Rollovers and Body Type

Rollover Type	Car/Van/Other (%)	SUV/Pickup (%)
None	95.03	81.60
1/4 turn	0.77	4.06
1/2 turn or greater	4.20	14.34

LTV body types were 3.7 times more likely to experience any degree of a rollover (1/4 turn or greater)

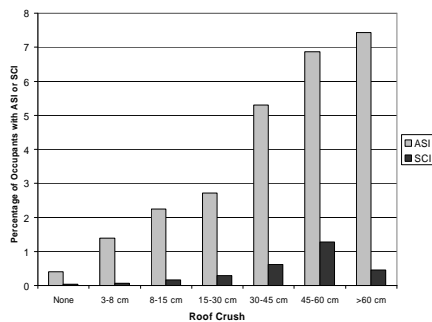
Source: NASS-CDS

Rollover Types with ASI-SCI

		ASI (%)	SCI (%)
Rollover Type			
	None	0.492	0.0494
	1/4 turn	1.308	0.161
	1/2 turn or greater	2.773	0.269
Vehicle Body Type			
	Car/Van/Other	0.617	0.064
	SUV/Pickup	0.862	0.086

Source: NASS-CDS includes those in multiple crash events

Roof Crush and ASI-SCI



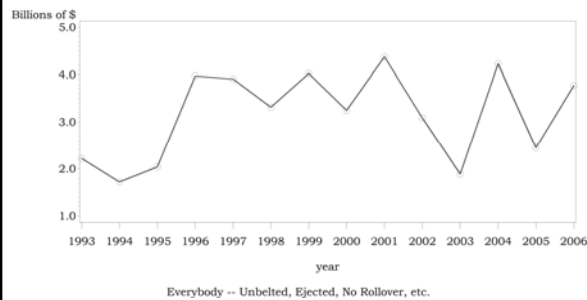
Yearly Expenses and Lifetime Costs Matched to AIS coding

Injury Severity	First Year	Subsequent Years	Lifetime (if injury age 25)
C1-C4	\$741,425	\$132,807	\$2,924,513
C5-C8	\$478,782	\$54,400	\$1,047,189
Paraplegia	\$270,913	\$27,568	\$977,142

A.I.S.
SCI codes

Source: National SCI Statistical Center

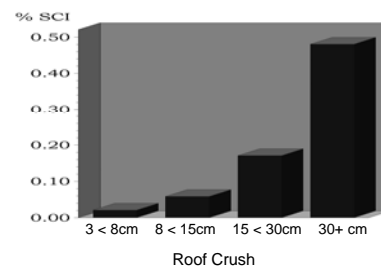
Annual Costs of SCI for All Crashes



Everybody -- Unbelted, Ejected, No Rollover, etc.

Source: NASS-CDS – Nationally all crashes involving SCI

Percent SCI by Roof Crush Among Belted Occupants



Source: NASS-CDS 1993-2006

CIREN Seattle Research Publications

Tencer A, Kaufman R, Ryan K, Grossman D, Henley MB, Mann F, Mock C, Rivara F, Wang S, Augenstein J, Hoyt D, Eastman B. Femur fractures in relatively low speed frontal crashes: The possible role of muscle forces. *Accident Analysis and Prevention*. 34(2002) 1-11.

Nirula R, Mock CN, Kaufman R, Rivara FP, Grossman D. Correlation of head injury to vehicle contact points using Crash Injury Research and Engineering Network (CIREN) data. *Accident Analysis and Prevention*, 35: 201-210, 2003.

Nirula R, Kaufman R, Tencer A. Traumatic brain injury and automotive design: making motor vehicles safer. *Journal of Trauma*, 55:844-8, 2003.

Acerno S, Kaufman R, Mock C, Rivara F, Grossman D. Vehicle mismatch: Injury patterns and severity. *Accident Analysis and Prevention* 39 (2004) 761-772.

Tencer A., Kaufman R., Mack C., Mock C. Factors affecting pelvic and thoracic forces in near-side impact crashes: a study of US-NCAP, NASS, and CIREN data. *Accident Analysis and Prevention* - 37 (2005) 287-293.

Tencer A., Kaufman R., Huber P., Mock C. "The Role of Door Orientation on Occupant Injury in a Nearside Impact: A CIREN, MADYMO modeling and Experimental Study." *Traffic Injury Prevention*, 6:372-378, 2005

CIREN Seattle Research Publications

Dissanaike S, Kaufman R, Mack CD, Mock C, Bulger E. The effect of reclined seats on mortality in motor vehicle collisions. *The Journal of Trauma, Injury, Infection and Critical Care*. 2008 Mar;64(3):614-9.

Bulger EM, Kaufman R, Mock CM. "Childhood Crash Injury Patterns Associated with Restraint Misuse: Implications for Field Triage." *Prehospital and Disaster Medicine* 2008;23(1):9-15

Francis DO, Kaufman R, Yueh B, Mock CM, Nathans AB. "Air bag induced orbital blow-out fractures" 2006. *Laryngoscope*, 116 September 2006

Bennet T, Kaufman, Schiff M., Mock C., Quan L. "Crash analysis of lower extremity injuries in children in forward-facing car seat during front and rear impacts." *The Journal of Trauma, Injury, Infection and Critical Care* 2006;61:592-597

Kuan JK, Kaufman R, Wright JL, Mock C, Nathans AB, Wessells H, Bulger E. – Renal injury mechanisms in motor vehicle collisions: analysis of the Crash Injury Research and Engineering Network (CIREN) dataset. *Journal of Urology* -Vol. 178, 935-940, September 2007

Liman K., Blackmore C., Kaufman R., Nguyen, T., Rott M., Stambaugh L., Jarkovich G., Mock C. Radiographic patterns of pelvic ring disruptions: Do initial radiographs tell the truth about the crash? *Journal of Orthopaedic Trauma*. 21(6):375-380, July 2007.